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First occurrence of *Mesocyclops aspericornis* (Daday, 1906) (Copepoda: Cyclopoida) in northern Colombia

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Abstract: The occurrence of the Afro-Asian freshwater cyclopoid copepod *Mesocyclops aspericornis* in the Gaira River, Magdalena, northern Colombia, represents the first record in the area and expands its known distributional range in South America. The specimens examined are described and compared with available morphological data. The variability of this species is confirmed among American and Afro-Asian populations but it was observed also between two Colombian populations. This record contributes to track the advancement of this introduced species in the Americas.

Key words: distribution; freshwater copepods; taxonomy; Neotropics

The freshwater cyclopoid copepod genus *Mesocyclops* Sars, 1914 currently comprises 103 nominal species and subspecies (Walter & Boxshall 2016). This genus is primarily tropical and subtropical (Gutiérrez-Aguirre et al. 2006) with a worldwide distribution in many different freshwater environments. Most of the known species (60%) are distributed in Africa and Asia (Holyńska et al. 2003). In the Neotropical region around 20 species have been reported (Gutiérrez-Aguirre et al. 2006) and of these, 6 have been recorded from Colombia: *Mesocyclops aspericornis* (Daday, 1906), *M. brasilianus* Kiefer, 1933, *M. longisetus* (Thiébaud, 1912), *M. meridianus* (Kiefer, 1926), *M. reidae* Petkovski, 1986, and *M. ellipticus* Kiefer, 1936.

Mesocyclops aspericornis is considered a pantropical species (Holyńska et al. 2003; Gaviria & Aranguren 2007); it was originally described from Sumatra, Singapore and Hawaii and has been recorded from Africa (Van De Velde 1984; Jeje 1988) and Asia (Lim & Fernando 1985; Baribwegure & Dumont 2000; Holyńska 2000). In the Americas it is believed to be an introduced species and has been reported from Venezuela (Infante et al. 1979; Dussart 1984), Colombia (Suárez et al. 1984; Petkovski, 1986), Argentina (Dussart & Frutos 1985), Brazil (Rocha & Botelho 1998), and Mexico (Gutiérrez-Aguirre et al. 2003; Elías-Gutiérrez et al. 2008; Suárez-Morales et al. 2011a). It is widespread among the Caribbean islands including Guadalupe and Martinique (Dussart 1982), Aruba, Curacao, Bonaire, U.S Virgin islands, Puerto Rico, Haiti, Jamaica, Grand Cayman, the Turks and Caicos, and Inagua (Pesce 1985). This exotic species have been successfully tested as biological control agents of mosquito larvae in Colombia (Suárez et al. 1984) as it has important features for this purpose (Suárez-Morales et al. 2003).

Hitherto, there are only three records of this species from Colombia: two localities in the central region's Cundinamarca and Antioquia departments, (Suárez et al. 1984; Reid 1987) and one record from the oceanic island of San Andres (Petkovski 1986). The species was also reported from the Antioquia department (Gaviria & Aranguren 2007) without details of its locality.

There are at least two recognized groups of *M. aspericornis* in the Americas, mainly characterized by the presence or absence of cuticular pits on the surface of the compound genital somite (Gutiérrez-Aguirre et al. 2003). It is possible that the American populations derived from distinct introduction processes. The present paper reports the first record of *M. aspericornis* in northern Colombia (Magdalena department), which expands the regional distributional range of this copepod in northern South America. Morphological details and a comparative analysis of the Colombian specimens are provided together with comments on the distributional advancement of this Afro-Asian species in the Americas.

Biological samples were collected from the Gaira River, Santa Marta Magdalena, Colombia, which is a typical mountain river with highly oxygenated waters and pH values close to 7 (Tamaris-Turizo et al. 2013). (11°11′12.5″ N, 074°13′08.50″ W) (Figure 1), during August 2015. A 25 L

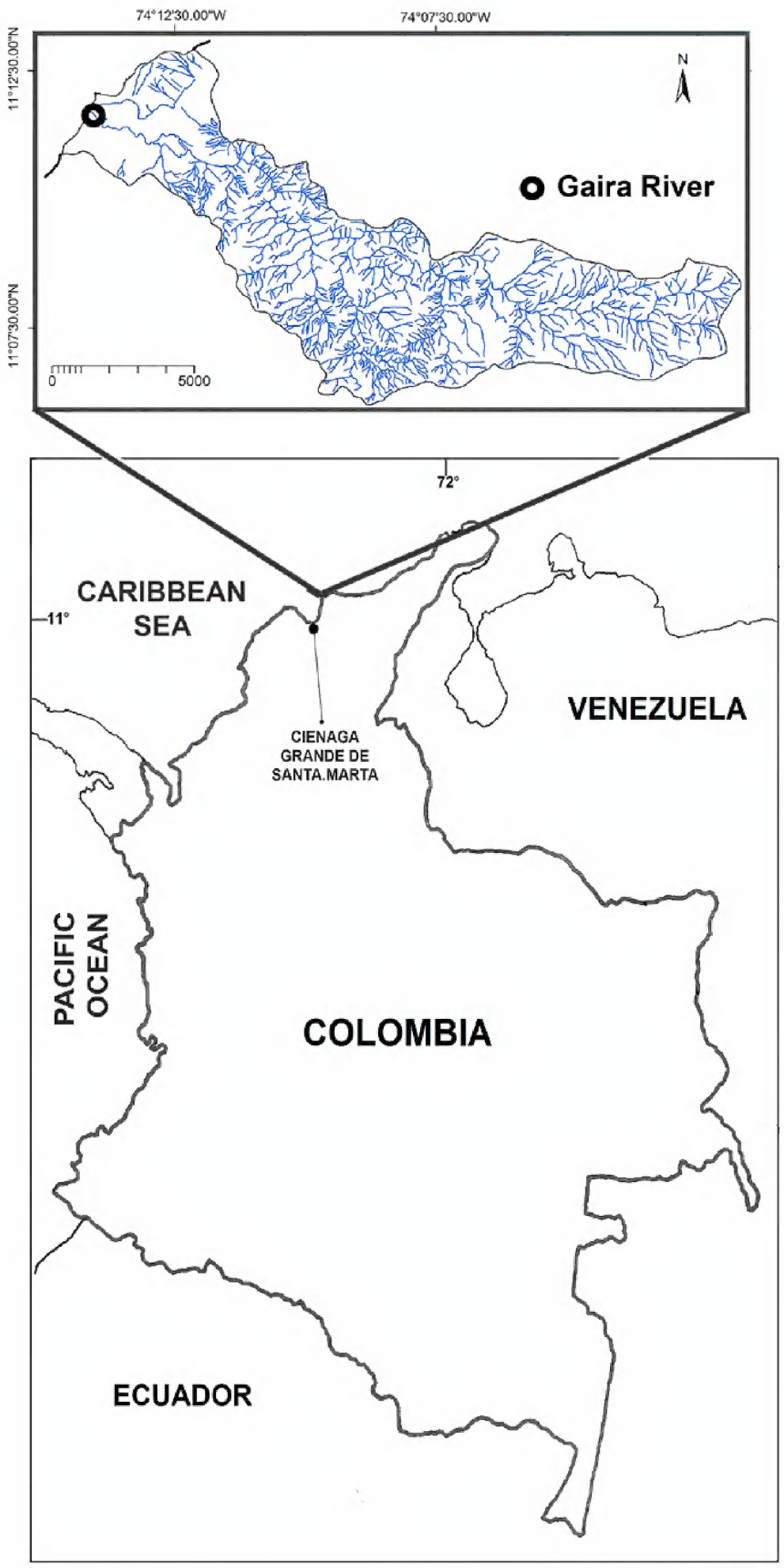


Figure 1. Surveyed area in the Basin of Gaira River, Colombia.

bucket was vertically hauled among submerged vegetation and then filtered with a 45 µm mesh size plankton net to obtain concentrates of 500 ml that were immediately preserved in 4% formalin. Samples were stained with Bengal rose and copepods were sorted out and embedded in lactic acid for dissection. Image acquiring was performed with a Kodak Easy Share C140 digital camera attached to a compound microscope. Individuals were measured in ventral position, from anterior end of the cephalothorax to the posterior margin of caudal rami, using an ocular micrometer. Voucher specimens were deposited at the Museo de Colecciones Biológicas de la Universidad del Atlántico, Barraquilla, Atlántico, Colombia (UARC394M). Abbreviations used are P1–P5 = legs 1-5, ENP = endopod, EXP = exopod.

Mesocyclops aspericornis (Daday, 1906), Figures 1–4

Synonyms. See Dussart & Defaye, 2006: 112–113.

Description. Total length of the specimens examined, measured from the anterior margin of cephalosome to posterior margin of caudal ramus averaged 1.26 mm (n = 8) (Figure 2). Genital compound somite with cuticular pits on both dorsal and ventral surfaces.

Antennules with 17 segments (Figure 3), with rows of spinules on segments 1, 4, 5, and 7–13 and integumental pits on segments 1, 4, 5, and 7–16. Hyaline membrane on segments 16 and 17, distal half of hyaline membrane on segment 17 with deep notch (Figures 4, 5); length ratio of segments 16/17 = 1.27.

Antenna represented by basipodite and a 3-segmented endopodite (Figure 6). Basipodite armed with 2 distal setae on inner ventral surface and single row of minute spinules on medial ventral surface which continues with a short row of spinules on the inner margin (Figure 7). Group of spinules present near insertion of apical setae (Figure 8) plus row of spinules on dorsal surface as shown in Figure 8.

Second endopodal segment with 8 setae (Figure 6). Antennal exopod represented by single strong pinnate seta. Mandible (Figure 9) with gnathobase bearing row of 10 wide-based, monocuspidal teeth, distal blade of 3 teeth, proximal seta with inner margin pinnate; mandibular palp with 2 long and single short setae, with 3 groups of spines near insertion of palp.

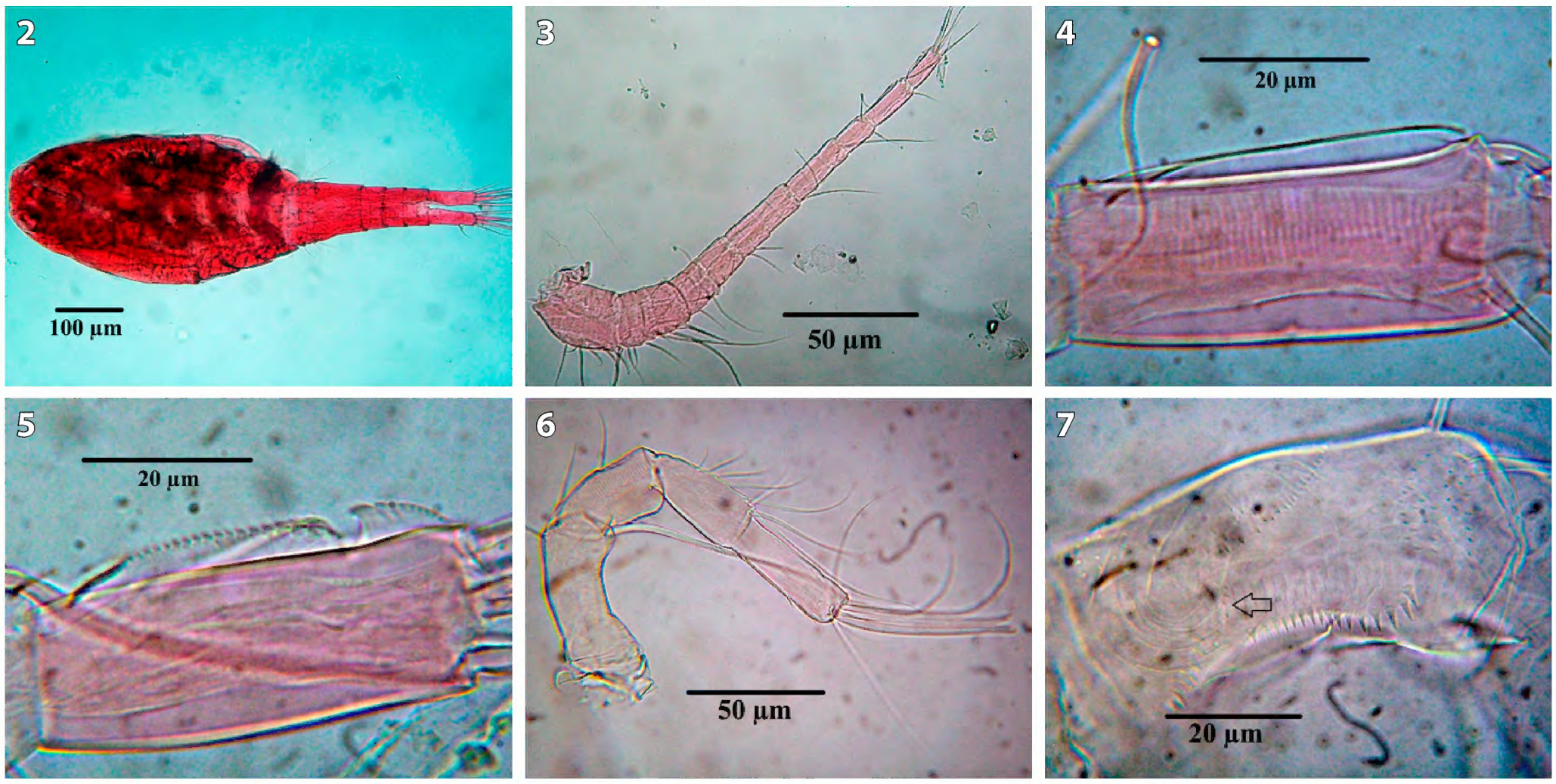
Maxilla (Figure 10) with syncoxa (praecoxa and coxa), basipodite and 1-segmented endopodite. Praecoxa with single endite armed with 2 spinulose setae. Coxa with 1 pinnate medial seta and endite with 2 distal setae. Basis forming stout claw-like process with pinnate seta and a slender seta on caudal surface. Endopod with 2 claw-like pinnate and 3 naked setae.

Maxillulary palp (Figure 11) naked, longest seta on lateral lobe without long setules.

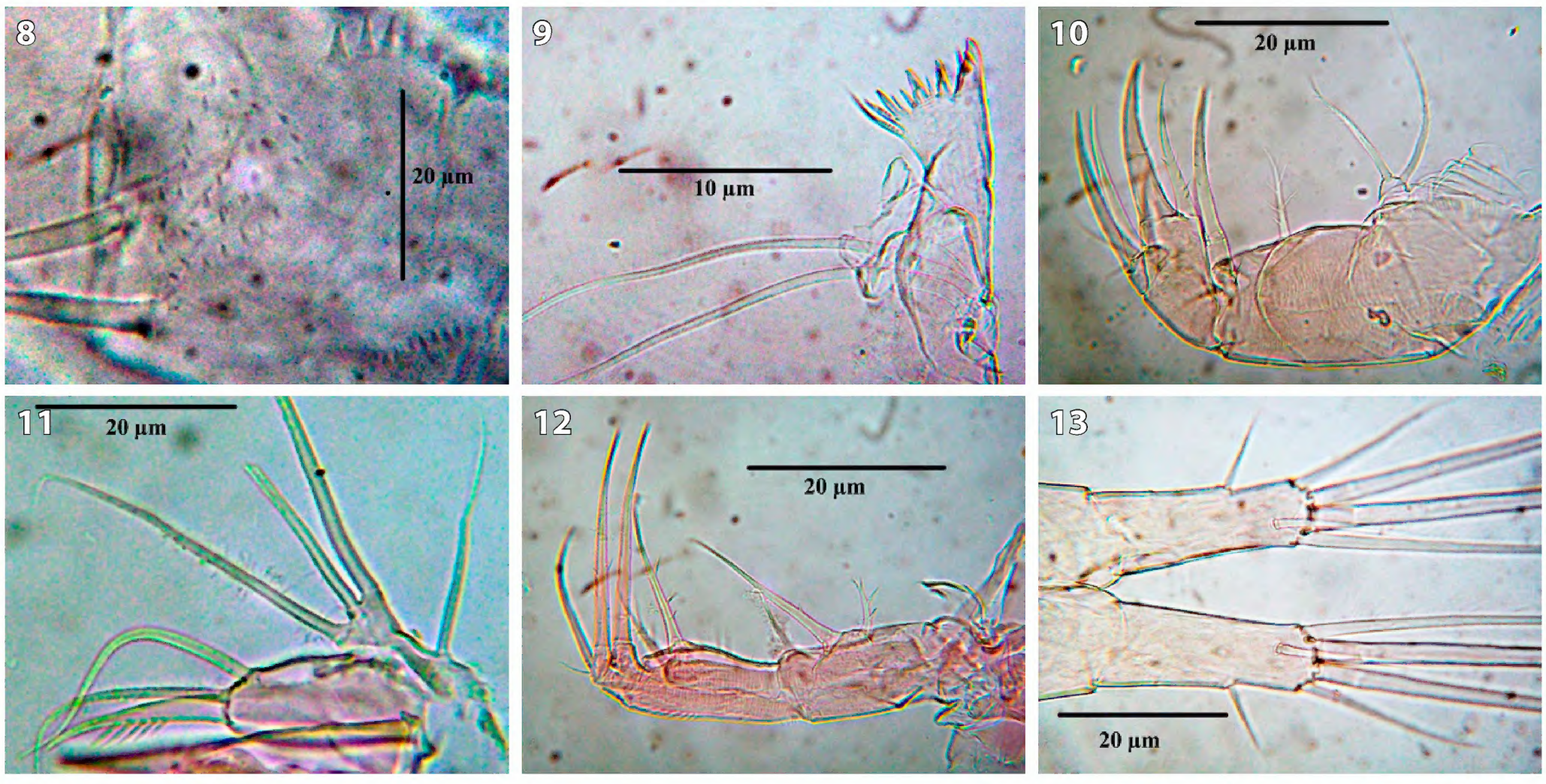
Maxilliped (Figure 12) 4-segmented, armed with 3,2,1, and 3 setae, respectively.

P1–P4 EXP and ENP 3 -segmented (Figures 14-17). Inner basipodal seta of P1 absent (Figure 14), intercoxal sclerite of P4 with low non-acute projection (Figure 18), length/width ratio of P4ENP3 = 2.2–2.3, inner distal spine of P4ENP3 about 1.42 as long as outer spine (Figure 19). P5 as described for the species (Figure 20). Caudal rami 2.7 times as long as wide (Figure 13). Inner margin of caudal rami lightly pilose (Figure 22).

The morphology of the eight adult female specimens from Magdalena, Colombia agrees in general with previous descriptions and illustrations of the species (Holyńska 2000; Dussart 1984; Petkovsky 1986; Gutiérrez Aguirre et al. 2003; Suárez-Morales et al. 2011a). *Mesocyclops aspericornis* can be recognized from its congeners by a unique combination of characters including: 1) antennary basis with a group of tiny spinules between proximal oblique and longitudinal spinule rows (arrow in Figures 7 and 21); 2) setules along the inner margin



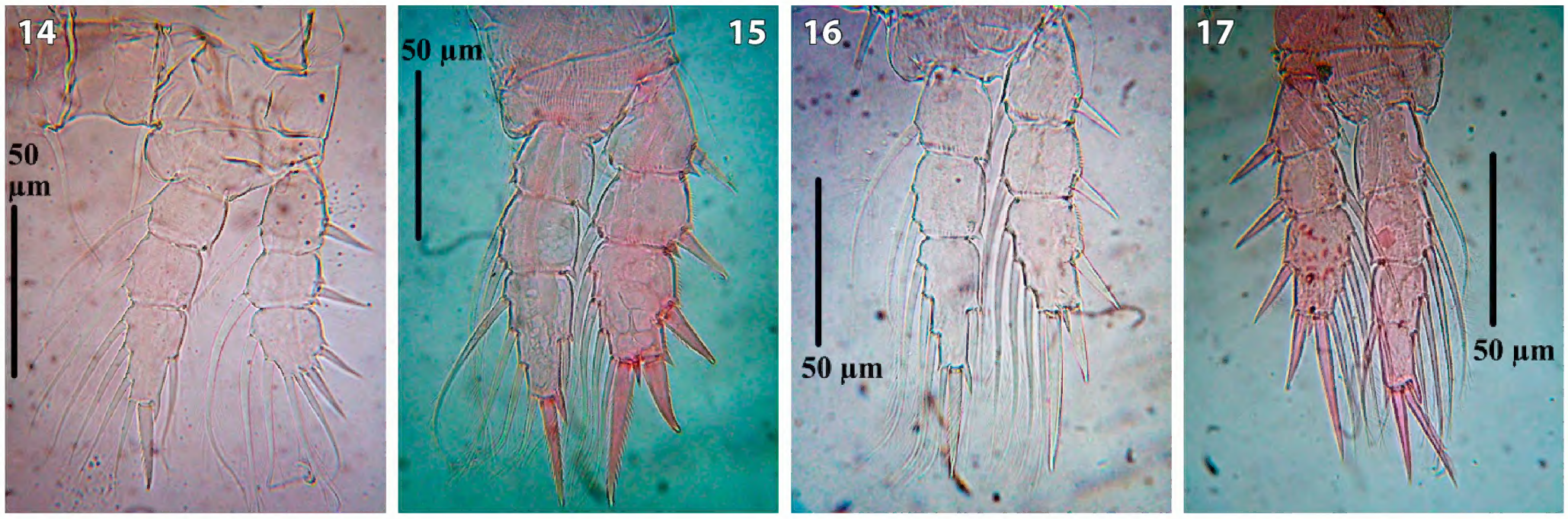
Figures 2–7. Adult female *Mesocyclops aspericornis* from Gaira River, northern Colombia. **2.** Habitus. **3.** Antennule. **4, 5.** Antennule segments 16 and 17. **6.** Antenna, ventral view, the arrow points at the pinnate seta. **7.** Same, basipodite, the arrow indicates the short row of minute spinules on the inner margin.



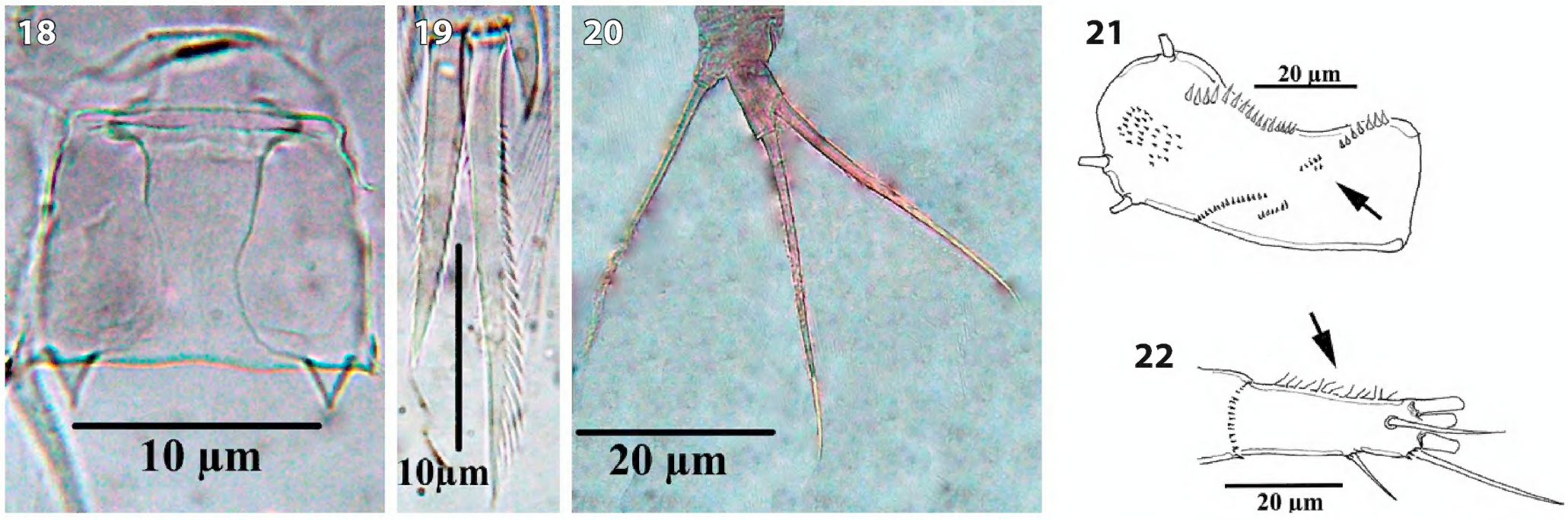
Figures 2–7. Adult female *Mesocyclops aspericornis* from Gaira River, northern Colombia. **2.** Habitus. **3.** Antennule. **4, 5.** Antennule segments 16 and 17. **6.** Antenna, ventral view, the arrow points at the pinnate seta. **7.** Same, basipodite, the arrow indicates the short row of minute spinules on the inner margin.

of the caudal rami (arrowed in Figure 22); 3) absence of inner basipodal seta on P1; 4) intercoxal sclerite of P4 with low, non-acute projection. These distinctive traits are also present in the Colombian specimens examined, thus its identity can be herein confirmed.

In terms of the well-known intraspecific variability of the species (Holyńska et al. 2003), specimens from Gaira River are identical in most aspects to those reported in the Colombian oceanic island of San Andrés (Petkovski 1986); however, they show subtle differences in the following characters: 1) length/width ratio of caudal rami is about 2.7 in the specimens from Gaira River (Figure 13) whereas it is 3.4 in specimens from San Andrés (Petkovski 1986: fig. 3); 2) the length/width ratio of P4ENP3 is about 2.2–2.3 in specimens from Gaira River (Figure 17) while it is 3.5 in the specimens from San Andrés (Petkovski 1986:



Figures 14–17. *Mesocyclops aspericornis* from Gaira River, northern Colombia. Adult female. 14. P1. 15. P2. 16. P3. 17. P4, ventral view.



Figures 18–22. *Mesocyclops aspericornis* from Gaira River, northern Colombia. Adult female. **18.**Coxal sclerite of P4. 19. Terminal spines of P4ENP3. **20.** P5. **21.** Antennary basipod, ventral view showing ornamentation and distinctive group of spinules (arrowed). **22.** Left caudal ramus, dorsal view showing caudal armature and ornamentation of inner margin.

fig. 7). Unfortunately, Suárez et al. (1984) did not provide illustrations of *M. aspericornis* from central Colombia (Cundinamarca), and thus, a comparison was not possible.

The specimens of *M. aspericornis* from Colombia are similar to those of other American populations as reported by Dussart (1984), Gutiérrez-Aguirre et al. (2003), Elías-Gutiérrez et al. (2008) and Suárez-Morales et al. (2011a), in the following characteristics: pitted antennulary segments, spinules pattern on the antennary basipodite, antennule spinulation pattern, structure of antennulary hyaline membrane, and ornamentation of caudal rami. This species shows additional differences with respect to reports from other geographic areas (Gutiérrez-Aguirre & Suárez-Morales 2001). The length/width ratio of the caudal rami ranges between 3.1 and 3.5 in American populations (Dussart 1984: figure 24; Petkovsky 1986; Suárez-Morales et al. 2011a, figure 1K; Elías-Gutiérrez et al. 2008, figure 52.10), which is similar to the range of African populations (3.0–3.4) (Kiefer 1981) but differs from that of Asian specimens (2.7–3.6) (Holyńska 2000: figure 22D; Pesce 1985: figure 51). The corresponding ratio of our specimens from Gaira River is 2.7, closer to that reported in Asian populations. In Mexican, African and Asian specimens the antennulary segments with rows of spinules are 1, 4, 5 and 7–13 (Kiefer 1981; Gutiérrez-Aguirre et al. 2003); the same pattern was observed in the Colombian population from the surveyed area. Integumental pits are present on antennulary segments 1–6, 14–16 in African specimens (Kiefer 1981) and in segments 1, 4, 5 and 7–16 in both the Mexican populations and our specimens from northern Colombia.

Another variable structure is the length/width ratio of P4ENP3 which is known to range between 2.5 and 3.5 in American populations (Dussart 1984: figure 24; Petkovski 1986: fig. 7; Gutiérrez-Aguirre et al. 2003: figure 4C; Suárez-Morales et al. 2011a: figure 1H). The range is different in African populations (2.4–3.1) (Kiefer 1981; Van de Velde 1984) and also in Asian specimens (2.4–3.0) (Holyńska 2000: figure 20E). The length/width ratio of specimens from Gaira River (2.2–2.3) is the smallest of all reported specimens of *M. aspericornis*.

The ratio of antennulary segments 16/17 of specimens of other American populations is 1.67 (Gutiérrez-Aguirre et al. 2003) and 1.25–1.40 in African specimens (Kiefer 1981; Van de Velde 1984), but there are no data on this character for Asian specimens. The ratio of both

our specimens from Gaira River and those from Venezuela is 1.27 (present data; Dussart 1984: figure 24 A1), and so resembles African populations.

The body size is also variable among different populations of *M. aspericornis*; it is about 1.17–1.60 mm in American populations (Gutiérrez-Aguirre et al. 2003; Petkovsky 1986; Suárez-Morales et al. 2011a; present data), and thus, differs slightly from both the African (1.18–1.50 mm) (Kiefer 1981; Van de Velde 1984) and the Asian populations (0.95–1.60 mm) (Pesce 1985; Holyńska 2000).

The number of setae on the second antennary segment is also regionally variable. For instance, specimens from the Neotropics have seven or eight (sometimes nine) setae (Elías-Gutiérrez et al. 2008; Suárez-Morales et al. 2011a), including our specimens from Colombia, whereas Asian populations always bear eight or nine setae (Holyńska et al. 2003).

This confirms the notion that *M. aspericornis* possess a high degree of morphological variability in many characters and could represent a species complex with active processes of speciation in different geographic regions. A similar morphological differentiation of introduced populations of freshwater cyclopoids was observed by Suárez-Morales et al. (2011b) in the Asian *Mesocyclops thermocyclopoides*. However, further investigation is necessary to confirm that *M. aspericornis* is undergoing a similar process, including a close analysis of the genital field and adjacent structures in these populations plus molecular studies to determine if these morphological differences are expressions of speciation.

Distribution. *Mesocyclops aspericornis* is considered an introduced species in the Americas (Reid & Pinto-Coelho 1994; Suárez-Morales et al. 2011a) and its dispersion trends are not fully documented. Considering the areas where *M. aspericornis* has been recorded in Colombia, two hypothesis could explain its spread in this country: 1) by activities related to the culturing of introduced fish species (i.e., *Oreochromis mossambicus*) in areas adjacent to the Gaira River; 2) by its dispersal from the Atlantic coast of Brazil and Argentina; *M. aspericornis* is a well-known fugitive species which is able to quickly colonize new habitats (Reid & Saunders 1986). This is thought to be the second record of this introduced species of Cyclopoida in continental Colombia and thus represents a northwards expansion of its known distributional range in South America and contributes to track the advancement over the continent.

Ecology. In the surveyed area, *M. aspericornis* was found to be related to the littoral microfauna, it was collected among vegetation. The water temperature varied over the seasons in the range of 26.4–28.9 °C; pH value during sampling was 7.7, conductivity 275 μS cm^{-1}, and solids totaled 234 mg/L. The presence of *M. aspericornis* in adjacent freshwater systems seems very likely, so a wider distribution in northern Colombia and adjacent areas might be expected.

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